DEPARTMENT OF HEALTH AND HUMAN SERVICES

Public Health Service

National Institute for Occupational Safety and Health
Robert A. Taft Laboratories
4676 Columbia Parkway
Cincinnati OH 45226-1998

12 July 2010
HETA 2010-0115

Fred Tremmel
Deepwater Horizon ICP
1597 Highway 311
Houma, LA 70395

Dear Mr. Tremmel:

On May 28, 2010, the National Institute for Occupational Safety and Health (NIOSH) received a request from BP for a health hazard evaluation (HHE). The request asked NIOSH to evaluate potential exposures and health effects among workers involved in Deepwater Horizon Response activities. NIOSH sent an initial team of HHE investigators on June 2, 2010, to begin the assessment of off-shore activities. To date, 26 HHE investigators have been on-scene; the investigation is continuing with efforts to assess on-shore response activities.

This letter is the second in a series of interim reports. As this information is cleared for posting, we will make it available on the NIOSH website (www.cdc.gov/niosh/hhe). When all field activity and data analyses are complete we will compile the interim reports into a final report.

This report (Interim Report #2) includes several discrete components of our investigation. For each, we provide background, describe our methods, report the findings, and provide conclusions and, where appropriate, interim recommendations. The components included in this report are as follows:

- 2A – Venice, Louisiana On-shore Infirmary Log Review
- 2B – Evaluation of June 8–10, 2010 In-situ Oil Burns
- 2C – Evaluation of June 25, 2010, Barge Oil Vacuuming Operations in Coup Abel Pass, off Grand Isle, Louisiana

As noted above, the NIOSH assessment of on-shore activities is on-going. In addition, NIOSH investigators are planning a new assessment component for off-shore activities. This will involve air and urine monitoring of specific exposures. The lead NIOSH investigators for this effort are Dr. Judith Eisenberg and Mr. Chad Dowell. They will contact you in the next few days to discuss our plans.

Thank you for your cooperation with this evaluation. If you have any questions, please do not hesitate to contact me at 513.841.4382 or atepper@cdc.gov.

Sincerely yours,

Allison Tepper, PhD
Chief
Hazard Evaluations and Technical
Assistance Branch
Division of Surveillance, Hazard
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3 Enclosures

cc:
Mr. David Dutton, BP
Mr. Mark Saperstein, BP
Dr. Richard Heron, BP
Dr. Kevin O'Shea, BP
Mr. Charles Huber, Manager, Dispersant Operations
LT John Kaser, USCG
Mr. Clint Guidry, LA Shrimp Association
Ms. Cindy Coe, OSHA
Dr. Raoul Ratard, LA DHHS
Mr. Brock Lamont, CDC
Dr. Donald Thibodeaux, Safety Management Systems
Mr. Ken Dartez, Safety Management Systems
Mr. Scott Henry, Safety Management Systems

Health Hazard Evaluation of Deepwater Horizon Response Workers HETA 2010-0115

Interim Report #2A Venice, Louisiana Branch Infirmary Log Review

Introduction

NIOSH investigators collected and reviewed daily infirmary logs from June 01–30, 2010, for response workers at the Deepwater Horizon Venice, Louisiana Branch Infirmary. This infirmary is staffed by contract paramedic personnel who provide basic first aid (one time treatment) and dispense over the counter (OTC), single dose medication as needed for minor injury or discomfort. Paramedics also assess and triage ill and injured workers, consult with the contracted physician as needed, and refer workers for further evaluation and treatment to either an on on-site mobile health care clinic staffed by personnel from the Department of Health and Human Services (DHHS) National Disaster Medical System, Disaster Medical Assistance Team (DMAT) or other health clinics or hospitals based on the nature of the injury or illness. These infirmary logs capture the chief complaint(s) of those reporting to the infirmary, and cannot be interpreted as medical diagnoses. This interim report summarizes the types of conditions seen and their disposition, and offers recommendations for future surveillance efforts. This report is separate from and in addition to the NIOSH Report of BP Illness and Injury Data (April 23 – June 6, 2010), which is based on incident reports recorded by BP safety officials in the field. That separate report (the NIOSH Report of BP Illness and Injury Data) is updated periodically and can be found at http://www.cdc.gov/niosh/topics/oilspillresponse/data.html.
The Louisiana Department of Health and Hospitals, Office of Public Health, also is conducting multi-source surveillance and issuing weekly reports that can be found at:
http://www.dhh.louisiana.gov/offices/publications/pubs-378/_OilSpillSurveillance2010_05.pdf.
Additionally, we reviewed a report prepared for BP entitled Deepwater Horizon Summary of Medic Log Data [4 May-29 June 10] which states it is based on data collected from BP medic logs submitted by all four contracted vendors across five states.

While in the field, HHE investigators discussed various preventive medicine topics and heat stress recommendations with on-site safety representatives. They provided CDC posters on personal hygiene, handwashing, and cough etiquette. The purpose was to augment existing prevention measures designed to limit the impact of illness due to infectious diseases, whose occurrence often is exacerbated during large-scale response activities where crowding, stress, long work hours, and poor hygiene often are present.

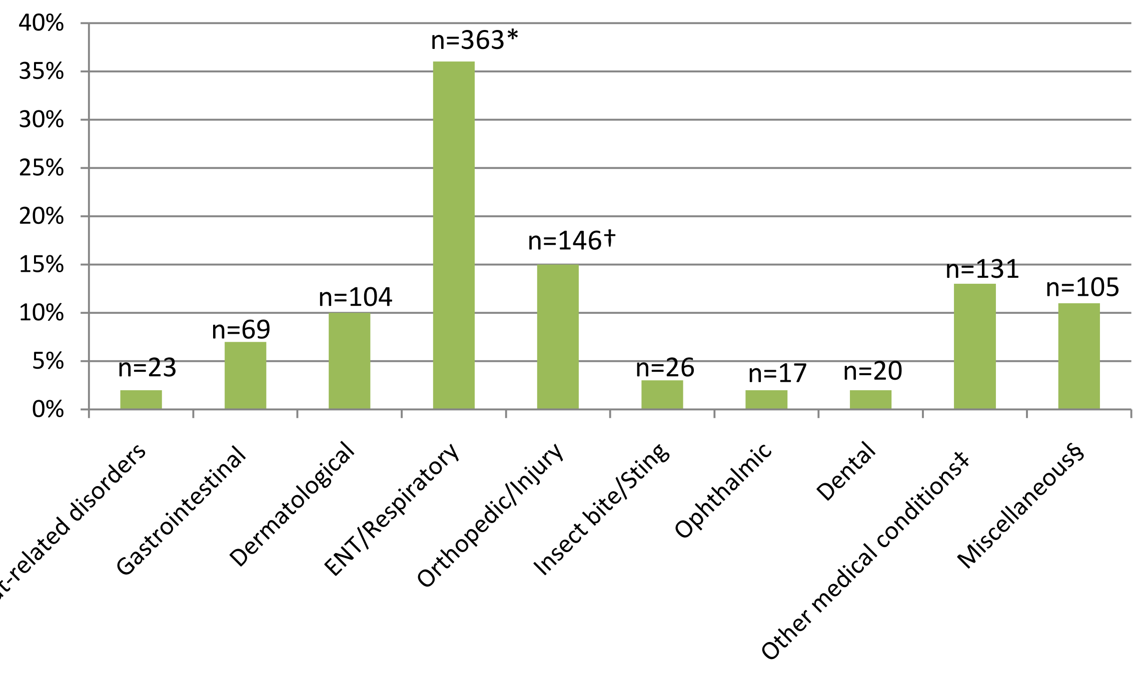
Evaluation

NIOSH investigators collected paper copies of infirmary logs from the Branch Infirmary in Venice, Louisiana from June 01–30, 2010. For this analysis, NIOSH investigators developed symptom groups based on groupings used by others in somewhat similar situations (i.e., heat stress, crowded living conditions, long work hours, and separation from family) [Gambel et al. 1999; Bohnker et al. 2005]. These groups were developed by the United Nations for medical surveillance during peacekeeping missions and the U.S. Department of Defense for disease and non-battle injury surveillance in deployment settings.

Results

Figure 1 shows the distribution of infirmary visits by complaint type for the Venice Branch Infirmary from June 01–30, 2010. Among the 1,004 reported visits, 363 (36%) were for ear, nose and throat (ENT) and respiratory complaints. The distribution of subgroups within this symptom group is shown in Figure 2. Orthopedic/Injury was the second most commonly reported complaint and was reported by 146 (15%) workers; the distribution by subgroup is shown in Figure 3. Although heat-related disorders were reported in only 23 (2%) workers, these numbers may be an underestimate. Since these logs are based on patient complaint rather than final diagnosis, non-specific signs recorded separately (e.g., headache, dizziness, cramps) could have been early signs of heat-related disorders. Ongoing prevention efforts to address heat related-disorders such as adequate hydration, work-rest cycles, and providing shade should continue to be stressed by safety personnel and heat stress advisors.

Figure 1. Visits by complaint type, Venice Branch Infirmary–June 2010, n=1004



* See Figure 2 for further explanation of ENT/Respiratory

† See Figure 3 for further explanation of Orthopedic/Injury

‡ Other medical conditions includes headache, infection (not specified), chapped lips, and other complaints not captured elsewhere and with 3 or fewer occurrences

§Miscellaneous: All other conditions not reported in other categories such as: blood pressure checks, bandage change, chapped lips, heartburn, questions, etc.

Figure 2 shows a further breakdown of ENT/Respiratory complaints. Among the 363 workers with respiratory complaints 230 (63%) were reported as sinus/congestion. A majority of these individuals received symptomatic therapy with OTC cold medications. Potential contributors to these reported upper respiratory complaints are seasonal allergies, irritation from road and gravel dust at the marina and docks used for Venice Branch operations, smoking and second-hand exposure to tobacco smoke, inadequate water intake, and upper respiratory infections resulting from crowded work and living conditions.

Figure 2.Type of Respiratory/ENT Complaint, Venice Branch Infirmary–June 2010, n=363

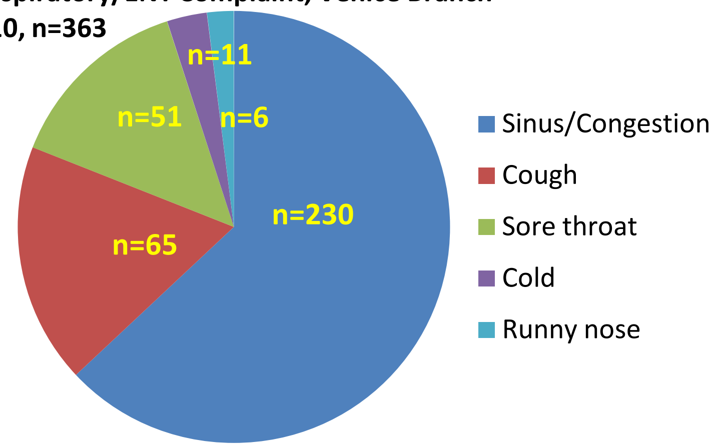
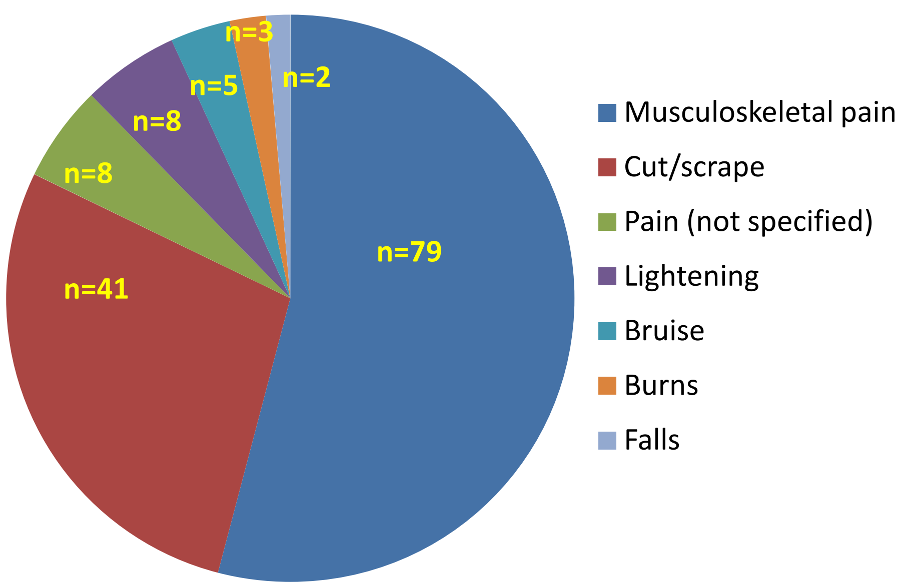


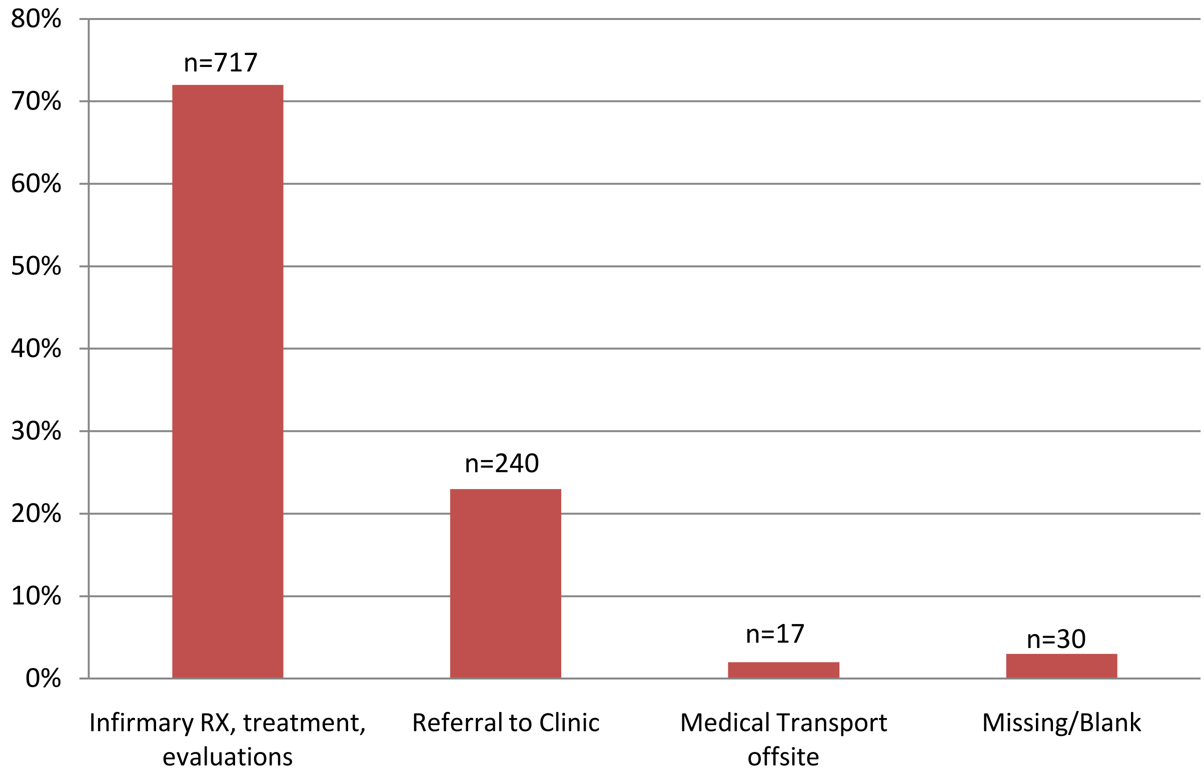
Figure 3 shows a further breakdown of Orthopedic/Injury complaints. Of the 146 total complaints, 79 (54%) were due to musculoskeletal pain involving many different body parts with no trends noted, while 1 (28%) workers reported a variety of cuts and scrapes.

Figure 3. Type of Orthopedic/Injury Complaint, Venice Branch Infirmary–June 2010, n=146



Response activities being conducted on the shores and water in the area surrounding Venice, Louisiana are very geographically isolated Most workers operating in this location have limited or no access to other sources of OTC medications, such as ibuprofen or cold and sinus medications. This contributed in part to the number of workers seeking medical care at the Venice infirmary. Figure 4 shows a breakdown of visits by disposition. Of the 1004 workers seen at this location, 717 (71%) were seen only for initial triage and OTC medication. NIOSH investigators did not have access to the clinical diagnosis and disposition of the 240 (24%) workers who were referred for further evaluation; this information is reported though other State or Federal surveillance systems. However, informal discussions with several local healthcare providers who reported seeing a variety of conditions similar to those reported here, revealed that injuries were the only type of visit directly attributable to response work. They did not report seeing occupational illness in workers from any work exposures.

Figure 4. Infirmary visits by Disposition–Venice, Louisiana, June 2010, n=1004



Discussion and Summary

Seventy-one percent of the infirmary visits were for conditions requiring one-time treatment on site. Other than symptoms related to working in the heat, and exacerbations of existing medical conditions due to a variety of reasons (heat, lack of continuity of care, etc.), our evaluation of the Infirmary data and interviews with the staff and other medical providers did not reveal unrecognized or unreported occupational illness due to workplace exposures. The information included in this interim report is subject to several limitations. The chief complaint reported on the infirmary logs and used in our analyses was self-reported by the worker, and was not a medical diagnoses. The conditions requiring one-time treatment usually are not considered to be occupationally-related, or OSHA recordable illness and injuries. Under-reporting of some conditions for the total Venice Branch may have occurred, as we only captured infirmary data at one location; medics were stationed off-shore and in other locations in the area. NIOSH investigators do not have information on the number of response workers eligible for care for the month of June, which would be needed to calculate incidence rates.

The total number of infirmary log visits recorded at the Venice Branch Infirmary from June 01-30, 2010 was 1004. In comparison, the total number of patient encounters reported in the Deepwater Horizon Summary of Medic Log Data [4May10-29June10] for the state of Louisiana was 1017. This comparison shows that existing medic log summary data reports currently available may not be capturing all data sources. The report entitled Deepwater Horizon Summary of Medic Log Data [4May10-29June10] states that it contains all data provided by BP HQ through June 30, 2010. However, our data shows that many of the infirmary visits were not captured in the summary data.

Recommendations

BP should continue to work with local, State, and Federal agencies to strengthen their system to comprehensively collect and analyze infirmary illness and injury data from all on and off-shore locations to allow the early detection of potential adverse injury and illness trends. Complete and accurate reporting and analysis are essential to developing timely and appropriate interventions. While acknowledging the logistical challenges posed by capturing these data from both on and off-shore medical locations spread across several states, ideally this information should be captured electronically to assist in data analysis. This will also help address potential over-reporting when individuals are seen in multiple locations for the same complaint, such as those individuals initially triaged at an infirmary then referred to other locations for evaluation. Updating local providers and health departments with current information about any changes in illness and injuries among responders would also be useful.

BP should continue following its Heat Stress Management Plan to reduce the risk of heat-related disorders in response workers, and should continually provide and emphasize preventive medicine measures such as providing hand washing stations and ensuring showers and restroom facilities/portable toilets are hygienically maintained. Because there are plans to increase the number of responders housed in central locations, involving local health departments to address many of these potential problems is recommended. Safety officials should also work closely with contracted food service vendors to ensure proper standards of food safety are followed. Options to control dust at work sites, especially in camp areas where large numbers of workers congregate such as dining and lodging areas, should be explored.

Workers should continue to be encouraged to report health concerns or injuries to their supervisor or on-scene safety representatives, and seek care through established on-site medical facilities or other healthcare providers as appropriate. Health and safety training should be provided to workers on an ongoing basis to prevent work-related injuries and illnesses. If healthcare is sought outside of the system established for this response, workers should clearly inform their healthcare provider about their job duties, potential exposures, and involvement in response activities to aid in their diagnosis and treatment.

NIOSH investigators would like to acknowledge the staff of the Venice, Louisiana Infirmary for their cooperation and assistance in data collection.

References

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Gambel J, Drabick J, Martinez-Lopez L [1999]. Medical surveillance of multinational peacekeepers deployed in support of the United Nations Mission in Haiti, June–October 1995. Int J Epidemiol *28*: 312-318.

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Interim Report #2
Evaluation of June 8–10, 2010 In-situ Oil Burns

Introduction

NIOSH industrial hygienists conducted industrial hygiene monitoring and administered health symptom surveys during in-situ (i.e., on site) burns of surface oil on June 8–10, 2010. The in-situ burn team was composed of a fleet of vessels divided into two task forces, Task Forces 1 and 2, located immediately outside a 3-mile radius surrounding the Deepwater Horizon oil spill well site in the Gulf of Mexico. Each Task Force had a lead vessel, three large support/safety vessels, and four pairs of shrimping trawlers (i.e., Teams 1–4 for Task Force 1, Teams 5–8 for Task Force 2). The trawlers towed boom to contain the surface oil for burning. Three rigid-hulled inflatable boats (RHIBs) from which the burns were ignited were available for each Task Force (i.e., RHIBs A–C for Task Force 1, RHIBs D–F for Task Force 2). These ignition boats were launched from the lead vessels and had either one or two 150-horsepower gasoline-fueled outboard engines.

The lead vessel of Task Force 1 was the Premier Explorer; Task Force 2's lead vessel was the Sea Fox. Each lead vessel was responsible for and controlled all aspects of the burn for its task force. Each carried approximately 30–35 personnel responsible for on-board command and control tasks including communicating with and directing all vessels involved in the burn operations, as well as on-deck operations such as using a crane to lift and move new and burnt boom. The support/safety vessels were responsible for assisting the lead vessel with monitoring the burns and for providing safety support and oversight to the trawlers.

Each shrimping trawler in the task force had a partner trawler to which it was paired for towing boom; each of these vessels was operated by a captain and two deckhands, all of whom worked and slept on the trawler for several weeks before returning to shore. These individuals, previously employed as shrimpers and fishermen, were contracted by BP to assist in the oil burn operations. Additionally, each pair of trawlers was assigned a safety officer (employed by Tiger Safety under contract to BP) who was present on one of the two trawlers during the day's work shift, but who returned to a lead or support vessel for berthing at night. The safety officer observed work safety practices of the trawler crew and conducted direct-reading air monitoring on the trawler deck using instruments such as a multi-gas meter to measure levels of hydrogen sulfide (H_2S), oxygen (O_2), carbon monoxide (CO), and the lower explosive limit (LEL), and a DataRam to measure airborne particles throughout the day.

Each shrimping trawler and its partner trawler towed one end of an approximately 300-foot long boom behind them, creating a U-shaped area to collect a quantity of surface oil suitable for burning. Two types of boom were used by the trawlers in the burn area: 3M Fire Boom, containing buoyant ceramic floats wrapped in a wire mesh; and Elastec Hydro-Fire® Boom, an inflatable boom containing tubing through which cooling water is pumped during burns by diesel-fueled pumps located on the trawlers' decks. When a sufficient quantity of suitable, fresh oil was collected within the boom, an ignition boat was sent to the area. The ignition boat was staffed by two individuals who were responsible for spotting and igniting the collected oil. One individual would manually ignite the fire by placing an ignition package into the pooled surface oil. The ignition package was constructed of a flare, two one-half-gallon jugs of fuel gel, and blocks of buoyant foam. The flare was lit on the ignition boat and placed into the oil, igniting it. If the first ignition package failed to ignite the oil, additional ignition packages would be placed into the oil until a fire was initiated. Once successfully lit, the ignition boat either moved to an area approximately 150–200 feet upwind to observe the burn or moved to another pair of trawlers to prepare another ignition. According to safety protocol, personal protective equipment (PPE) to be worn at all times by ignition boat personnel included safety glasses, steel-toed boots, and a personal floatation device (PFD). Additionally, flame resistant coveralls and leather gloves were to be worn during ignitions.

During the burns, the trawlers slowly moved forward towing the boom to continually feed new surface oil into the fire. The duration of the burn depended on the quantity of oil enclosed by the boom and ranged from 45 minutes to 6 ½ hours. Relatively flat seas were required for burn operations to proceed and swells of several feet would postpone operations for all vessels. Decisions for postponement of operations were made by on-site operations command staff. Typically, one to five burns could be conducted by each trawler pair per day. During a burn, the trawlers were located approximately 300 feet from the area within the boom where the burn was occurring. As with all vessels in the area, the trawlers were instructed to maintain a position upwind from the smoke plume to minimize exposures to the by-products produced during the burn.

Evaluation

On June 8–9, 2010, two NIOSH industrial hygienists conducted personal breathing zone (PBZ) and area air sampling on shrimping trawlers towing boom during in-situ burns and on ignition boats. Both shorter-term and longer-term air samples were collected. The shorter-term samples represented exposure during specific activities or work tasks and the longer-term samples more closely represented full-shift occupational exposures. While a work shift might last up to 12 hours, this time included travel as well as boom preparation and deployment in the early hours of the morning prior to the start of oil burns. Longer-term sampling was initiated by the industrial hygienists upon arrival on the vessels in the morning. Typically, longer-term sampling commenced one to two hours after the start of the work shift, but prior to the first burn of the day, and continued through the completion of burns at the end of the work shift, a period of 8–10 hours.

On June 8, 2010, one NIOSH industrial hygienist was stationed on one of Team 1's shrimping trawlers, the Dustin Michael, which towed 3M Fire Boom with its partner, the Anna Marie. On this day, the Dustin Michael was involved in four burn operations; these burns ranged in time from 40 minutes to less than 2 hours. The captain and deckhands directed and maintained the trawler throughout the day, spending time both inside the cabin and outside on the deck. A contract safety officer present throughout the work shift on the Dustin Michael spent the majority of their time outside on the deck. Longer-term PBZ samples for volatile organic compounds (VOCs) and aldehydes were collected on the safety officer. Shorter-term area air samples were collected on the vessel's deck to screen for VOCs during two separate burns. Longer-term area air samples were collected for VOCs, aldehydes, carbon monoxide

(CO), hydrogen sulfide (H_2S), benzene soluble total particulate fraction, diesel exhaust, and mercury outside on the deck of the vessel.

A second NIOSH industrial hygienist was on board the ignition boat RHIB C. Two RHIB C workers were present on this boat; one controlled the boat while the second lit the ignition package and placed it into the pool of oil. These activities were not individually assigned, but were completed by both individuals interchangeably throughout the day. RHIB C ignited three burns of oil corralled by three different pairs of trawlers throughout the day. Longer-term PBZ samples for VOCs, aldehydes, CO, and H_2S were collected on one ignition boat worker during ignition activities, oil spotting, and boom repair; shorter-term PBZ samples were collected for VOCs on the second worker during one oil ignition event. Shorter-term area air samples were collected to screen for VOCs and longer-term area air samples were collected for VOCs, benzene soluble total particulate fraction, diesel exhaust, and mercury. For the area air samples, sampling equipment was placed on the boat's driving console, located in the center of the boat.

On June 9, 2010, one NIOSH industrial hygienist was on board Team 2's Gulf Rambler shrimping trawler along with one captain, two deckhands, and one safety officer. The Gulf Rambler and its partner, the Bub-Poot Nae, towed Elastec Hydro-Fire® Boom. Two burns were conducted throughout the day; the first lasted approximately 30 minutes while the second lasted approximately 50 minutes. On the deck of the vessel, two diesel fuel pumps were activated to pump water through the booms and were run before and throughout the burns. Longer term PBZ samples were collected for VOCs, aldehydes, and CO on the trawler's captain. Outside on the deck of the vessel, shorter-term area air samples were collected to screen for VOCs during specific burn activities; longer-term area air samples were collected for VOCs, aldehydes, CO, H_2S, benzene soluble total particulate fraction, diesel exhaust, and mercury. Longer-term area air samples for VOCs were collected inside the cabin.

The second NIOSH industrial hygienist was on board ignition boat RHIB A. Two RHIB A workers were also present on this boat. Four burns were ignited throughout the day. Longer-term PBZ samples were collected for VOCs, aldehydes, and CO on one RHIB A worker during ignition and spotting of oil, while longer-term PBZ samples were collected for VOCs and H_2S on the second RHIB A worker. Shorter-term area air samples were collected to screen for VOCs while spotting for oil, observing an oil burn, and igniting a burn. Longer-term area air samples were collected for VOCs, benzene soluble total particulate fraction, diesel exhaust, and mercury.

To evaluate the presence of VOCs, the NIOSH industrial hygienists used integrated air sampling with a variety of sampling media, including multi-sorbent thermal desorption tubes followed by thermal desorption/gas chromatography-mass spectrometry (NIOSH Method 2549); Summa canisters analyzed for selected contaminants by gas chromatography-mass spectrometry (EPA Method TO-15); and activated charcoal tubes [EPA 1999; NIOSH 2010]. Results of the thermal desorption tubes and Summa canister area air samples were used to select specific VOCs for quantitation on PBZ and area air samples collected using charcoal tubes. Other chemicals measured in PBZ or area air samples using integrated air sampling techniques included aldehydes (formaldehyde, acetaldehyde, and acrolein), diesel exhaust, mercury (a possible component of crude oil), and the benzene soluble fraction of total particulate samples. Direct reading measurements were made for CO and H_2S. Direct reading measurements were also recorded for temperature and relative humidity. See Table 1 for a complete listing of sampling and analytical methods used.

At the end of each of the two days of sampling, the NIOSH industrial hygienists returned to their berths on the lead vessel, Premier Explorer, where they performed post-calibration of sampling pumps and they refrigerated samples collected during that day. (With the exception of Summa canisters, all samples were also kept cold during shipment to the labs for analysis.)

Because of concerns about the possibility of acute health effects during the burning of oil, NIOSH industrial hygienists distributed and collected health survey forms on June 10, 2010. These surveys were distributed on the Premier Explorer at the morning safety meeting to many of the response workers who ignite the fires, maintain the boom, supervise/direct the burns, or perform support activities. On the Sea Fox, the surveys were distributed throughout the day to the same types of workers. The survey was given to response workers on the lead vessels on a day when no burning was performed due to rough seas which also prevented inter-boat transfers of personnel. All respondents were asked to assess the specific symptoms they had experienced since they had begun working on the in-situ burn team.

Results

Table 2 contains a summary of the relevant occupational exposure limits (OELs) to which results were compared. Table 3 presents temperature and relative humidity (RH) measurements made during the two days of the evaluation on the vessels where sampling was conducted by NIOSH industrial hygienists. The temperature on the decks of the vessels ranged from 83–88°F and the RH from 58–78%.

Volatile Organic Compounds

One longer-term and one shorter-term area air sample were collected using Summa canisters on both the Dustin Michael and RHIB C on June 8, 2010. The longer-term samples were collected over 8–10 hours; the shorter-term samples were collected over approximately 30 minutes. The shorter-term sample on the Dustin Michael was collected during that boat's first burn of the day; the shorter-term sample on the RHIB C was collected during and after that boat's second burn ignition of the day. On June 9, 2010, one longer-term area air sample was collected on the Gulf Rambler using a Summa canister over 9 hours and two shorter-term area air samples on RHIB A were collected over 30 minute periods using Summa canisters. The two shorter-term samples taken on the RHIB A were collected while observing a burn and while spotting for oil. The longer-term air samples from both days were compared against work-shift OELs and the shorter-term air samples were compared against short-term exposure limits (STELs) or ceiling limits. For the longer-term air samples, of all VOCs, benzene was measured in the highest concentration relative to its work-shift OEL. However, the maximum concentration of benzene was <4.1% of the NIOSH REL (0.1 parts per million, ppm). For the shorter-term air samples, naphthalene and benzene were measured in the highest concentrations relative to their STELs. However, the maximum concentration of naphthalene was <0.006% of the NIOSH and ACGIH STEL (15 ppm), and the maximum concentration of benzene was <0.3% of the NIOSH STEL (1 ppm). Even on an additive basis, for any given exposure period, the mixture of VOCs measured in the air was a fraction (<5%) of the acceptable levels.

On June 8, 2010, two shorter-term thermal desorption tube area air samples were collected on both the Dustin Michael and RHIB C to screen for VOCs. The samples on the Dustin Michael were collected during individual burns and the samples on the RHIB C were collected during and after two separate burn ignitions. On June 9, 2010, four shorter-term thermal desorption tubes samples were collected on the Gulf Rambler and three on the RHIB A. The four samples on the Gulf Rambler were collected during the following activities: pumping water into the Hydro-Fire® Booms via diesel pumps prior to the first burn of the day; during the first burn of the day while diesel pumps were operating; during no burn and no pumping activities (i.e., background); and during the second burn of the day while diesel pumps were operating. The three samples on the RHIB A were collected during periods when the vessel workers were spotting for oil, while watching a burn, and during and after the first burn ignition of the day. The screening samples contained a variety of substances. Major compounds detected were C_6–C_{15} aliphatic hydrocarbons as well as some benzene, toluene, xylenes, isooctane, biphenyl, and naphthalene. Alkyl substituted naphthalenes and tetrahydro alkyl naphthalenes were also present, as were trace amounts of other substances.

Based on the results of the Summa canisters and thermal tube screening samples, the PBZ and area air charcoal tube samples were quantitated for benzene, ethyl benzene, naphthalene, toluene, total hydrocarbons (THC) (as hexane), and xylenes. Results are shown in Tables 4–7. All air concentrations were well below the relevant OELs.

The charcoal tube PBZ samples taken onboard the Dustin Michael on June 8, 2010, (Table 4) were longer-term samples collected on the safety officer who was present outside on the deck during the majority of the day, during which four burns occurred. The compounds on these samples found at levels above the minimum quantifiable concentration were ethyl benzene, toluene, xylene, and total hydrocarbons. Specifically, total hydrocarbons were present at 4.7 milligrams per cubic meter (mg/m^3). The PBZ samples taken on board the Gulf Rambler on June 9, 2010, (Table 6) were full-shift samples collected on the captain of the vessel, who spent time both on deck and in the cabin throughout the day, during which two burns occurred. Only total hydrocarbons, with a concentration of 1.1 mg/m^3, were found above the minimum quantifiable concentration.

Over two days, four PBZ samples were collected using charcoal tubes on workers on the RHIBs. Three were longer-term samples and one was a shorter-term sample (Tables 5 and 7). Compounds found above the minimum quantifiable concentrations on all samples were toluene, xylene, and total hydrocarbons, with ethyl benzene found on three samples and benzene on one. For the two PBZ samples collected on June 8, 2010, total hydrocarbon concentrations were 8.5 and 9.1 mg/m^3. Total hydrocarbon concentrations for the two PBZ samples on June 9, 2010, were 1.1 and 2.8 mg/m^3.

Even on an additive basis, for any given exposure period, the mixture of chemicals measured in the air was a fraction (<10%) of the acceptable levels. Total hydrocarbon concentrations were all less than 10 milligrams per cubic meter (mg/m^3). Although there is no OEL specifically for THCs, OELs for petroleum distillates and kerosene (two mixtures containing a similar range of hydrocarbons as was found on the thermal tube air samples) are 350 mg/m^3 as a work-shift time weighted average as shown in Table 2.

To evaluate a potential concern that high humidity may affect adsorption of contaminants on charcoal sampling media, a comparison was made between concentrations reported on the charcoal tube and those measured using the Summa canister area air samples. Because Summa canisters collect a grab sample of air as it is present in the environment at the time of sampling and do not rely on adsorption of sample media, they are unaffected by high humidity. On both June 8 and 9, 2010, longer-term area air samples on the decks of the Dustin Michael and the Gulf Rambler were collected using side-by-side charcoal tube and Summa canister samplers. Results were compared for benzene, ethyl benzene, toluene, and xylenes. On June 8, 2010, the concentrations reported for the charcoal tube vs. Summa canister were <0.0005 ppm vs. 0.00032 ppm (benzene); 0.0017 ppm vs. 0.00066 ppm (ethyl benzene); 0.0020 ppm vs. 0.0012 ppm (toluene); and 0.0049 ppm vs. 0.0037 ppm (xylenes). On June 9, 2010, the concentrations reported for the charcoal tube vs. Summa canister samplers were 0.0027 ppm vs. 0.00042 ppm (benzene); 0.0011 ppm vs. 0.00081 ppm (ethyl benzene); 0.0023 ppm vs. 0.0017 ppm (toluene); 0.0042 ppm vs. 0.0033 ppm (xylenes). The very close results returned from both methods, particularly at concentrations in the parts per billion range, demonstrate the effectiveness of both charcoal tubes and Summa canisters in this environment and provide confidence that adsorption of contaminants on charcoal were not adversely affected by high humidity.

Aldehydes

On June 8–9, 2010, six PBZ and two area air samples were collected for aldehydes on the shrimping trawlers and RIHBs. The samples were quantitated for acetaldehyde, acrolein, and formaldehyde. None of the samples contained detectable concentrations of these aldehydes (Tables 4–7). The minimum detectable concentrations ranged up to 0.007 ppm for acetaldehyde, 0.04 ppm for acrolein, and 0.02 ppm for formaldehyde. The samples were screened for furfural, propionaldehyde, and valeraldehyde but none was detected.

Benzene Soluble Total Particulate Fraction

Four area air samples were collected for total particulates with the particulate fraction analyzed for benzene soluble components (to separate out contributions from substances such as salts from the sea water) as an indicator of oil mist exposures (Tables 4–7). One longer term sample collected on the Dustin Michael on June 8, 2010, had a trace concentration of 0.059 mg/m^3, well below the OEL of 0.5 mg/m^3. All other samples were non-detectable (less than 0.06 mg/m^3).

Carbon Monoxide and Hydrogen Sulfide

Tables 4–7 include a summary of the direct reading measurements for CO and H_2S. CO, a component of incomplete combustion, was monitored for approximately 8 to 12 hours on the vessels and RHIBs on June 8–9, 2010. On the shrimping trawlers, area and PBZ concentrations of CO ranged up to 17 ppm, with TWAs all less than 2 ppm, well below OELs. On the RHIBs, PBZ concentrations of CO ranged up to 220 ppm, with TWAs of 3 ppm. The NIOSH REL ceiling limit of 200 ppm was not exceeded on June 8, 2010, on RHIB C; however, a peak of 155 ppm was recorded. RHIB C was equipped with one 150-horsepower gasoline engine. The NIOSH REL ceiling limit of 200 ppm was exceeded one time on June 9, 2010, aboard RHIB A, with a high peak of 220 ppm. RHIB A was equipped with two 150-horsepower gasoline engines. Based on observations by the NIOSH industrial hygienist on board the RHIB boats both days, peak CO exposures occurred during activities in which the gasoline-powered boats were idling, suggesting that the exposure was a result of engine exhaust rather than from burning surface oil. The engines positioned on the deck of the Gulf Rambler for pumping water through the Hydro-Fire® Booms were fueled by diesel. Diesel engines typically produce considerably less CO than gasoline engines. In contrast to the peaks of 220 ppm seen on the RHIBs, a peak of only 17 ppm was seen on the area air sample on the Gulf Rambler during diesel engine operations. This peak, in particular, was a result of placing the CO monitor close to the diesel engine exhaust pipe for a few minutes and did not represent the exposure level on the deck in general. H_2S was not detected on four long term samples collected on the deck of the trawlers and RIHBs on June 8–9, 2010.

Diesel Exhaust

Emissions from diesel engines used to power the vessels or pump water through the Hydro-Fire® Booms are complex mixtures of gases and particulates. NIOSH uses elemental carbon (EC) as a surrogate index of exposure because the sampling and analytical method for EC is very sensitive, and a high percentage of diesel particulate (80–90%) is EC. In comparison, tobacco smoke particulate (a potential interference when measuring diesel exhaust) is composed primarily of organic carbon (OC). Although OSHA and NIOSH have established OELs for some of the individual components of diesel exhaust (i.e., nitrogen dioxide, CO), neither agency has established an OEL for EC. However, the California Department of Health Services' Hazard Evaluation System & Information Service (HESIS) guideline for diesel exhaust particles (measured as EC) is 20 micrograms per cubic meter ($\mu g/m^3$) for an 8-hour TWA. As shown in Tables 4–7, EC concentrations from four longer-term area air samples collected during in-situ burns were 2.9 and 3.7 $\mu g/m^3$ on the RHIBs and 2.4 and 6.2 $\mu g/m^3$ on the trawlers. The 6.2 $\mu g/m^3$ concentration was recorded on the deck of the Gulf Rambler, where two diesel engines were running throughout the day. All concentrations for diesel exhaust were below the HESIS guideline. Furthermore, diesel exhaust was not a substantial part of these sample results because the ratio of EC to total carbon (the sum of EC + OC) ranged from 6.0% to 12%, well below the expected 60% to 80% of EC to total carbon typically reported in diesel exhaust. These low diesel exhaust exposures are similar to those measured on Deepwater Horizon response workers by NIOSH investigators during a June 4–5, 2010, dispersant mission involving the M/V International Peace and M/V Warrior.

Mercury
No mercury was detected in four area air samples collected on June 8–9, 2010, as shown in Tables 4–7. The minimum detectable concentrations were 0.00002 mg/m^3, well below the most protective OEL of 0.025 mg/m^3. This is consistent with findings from a NIOSH June 4–5, 2010, exposure assessment of dispersant release activities on board the M/V Warrior and M/V International Peace.

Health Symptom Surveys
Thirty-nine persons (17 from Premier Explorer and 22 from Sea Fox) out of a total of approximately 65 workers on the two lead vessels completed the health symptom survey, including a number of individuals who conducted the oil ignitions for which personal exposure monitoring was performed during the assessment. Demographically, the workers on the two vessels were similar (Table 8). Reported symptoms, grouped by type, are presented in Table 9. This table includes symptoms for workers surveyed on the two vessels and a comparison group of workers recruited at the Venice Field Operations Branch and the Venice Commanders' Camp who reported that they had not worked on boats and had no exposures to oil, dispersant, cleaner, or other chemicals.

Overall, workers on the Sea Fox reported more symptoms and more types of symptoms than workers on the Premier Explorer, and workers on both vessels reported more symptoms than the comparison group. The most frequently reported symptoms on both vessels were similar: upper respiratory symptoms and constitutional symptoms (i.e., headaches and fatigue). Workers on the Sea Fox also reported itchy eyes, coughing, musculoskeletal pain (i.e., hand, shoulder or back pain), and psychosocial symptoms (i.e., feeling worried, stressed, pressured, depressed, short tempered, or frequent mood changes). These symptoms were less frequently reported or absent among workers on the Premier Explorer. Scrapes and cuts were the most frequently reported injuries on both vessels.

Summary

The types of symptoms reported were similar to those reported by response workers who were not exposed to hazards related to in-situ burning but overall workers involved in the in-situ burn did report a higher frequency of symptoms than the comparison group. Because the sample of workers involved in in-situ burning was very small, it is not possible to make statistical comparisons between the groups. It is not certain whether these findings can be generalized to workers on other vessels who may be working under different conditions. Some reported symptoms might have been related to a combination of several factors, including air contaminants from the in-situ burn, heat and humidity, sun exposure, and psychosocial stress.

In-situ burn team vessels work in and around fresh crude oil which may have the potential to emit more VOCs compared to weathered oil that has migrated substantial distances away from the oil source area. Hazards from in-situ burns include heat, exposure to products of combustion and, rarely, flash fire. Products of combustion a complex mixture of particulate matter, smoke and soot; VOCs such as partially oxidized alcohols, aldehydes, and ketones; metals; and gases such as carbon dioxide and CO [Fingas et al., 1993, Fingas et al., 1994]. The chemical composition of these emissions varies based on the oil composition, weather conditions during each burn, and the completeness of the combustion process. Based on sampling conducted over two days on ignition boats and vessels towing boom during burns, NIOSH investigators found exposures for all compounds sampled to be well below applicable OELs. One exception was the peak exposures to CO recorded on the RHIBs due to exhaust from gasoline powered engines.

Recommendations

As noted, CO exposures above the NIOSH REL ceiling limit were observed to occur during times when the gasoline powered engines were idling and no movement of the boats was occurring. This allowed the engine exhaust to build to a level above the NIOSH ceiling limit for CO. NIOSH industrial hygienists recommend that RHIB workers minimize engine idling times to prevent such CO buildup. Portable direct-reading CO monitors can also be placed on these boats to allow workers to monitor the level of CO and to take action to reduce their exposures, including turning the engines off or relocating to a new position rather than idling in one location. Regular maintenance of RHIB engines is also recommended to minimize the amount of CO produced during use.

NIOSH industrial hygienists visually assessed the potential for dermal exposures among in-situ burn team workers. In general, minimal opportunities for dermal contact with oil were observed. Activities with greater opportunity for dermal exposures included: handling oil-coated ropes that had been used to tow boom from the trawlers; contacting surface oil from splashes while traveling at high speeds on the RHIBs; and performing maintenance on the Hydro-Fire® Boom after burns. During maintenance of the Hydro-Fire® Boom, workers from the ignition vessels replaced bladders in the booms; during this task, dermal contact with oil or burn products occurred over the extent of the workers' forearms. No gloves were worn during this maintenance operation which lasted up to 1 hour. After finishing the operation, the workers cleaned their arms with a citrus hand cleaner. NIOSH industrial hygienists recommend that all workers with the potential for dermal exposure in these types of activities wear gloves of sufficient length to protect against unnecessary exposures.

While on the RHIB, it was observed that workers conducting ignitions did not fully comply with safety protocol in the PPE worn. As previously described, protocol dictates the use of flame-resistant coveralls and leather gloves by the individual placing the ignition package into the oil for ignition. On several occasions, it was observed that only the top half of the coveralls was donned (i.e., the legs of the coveralls were not stepped into) and no gloves were worn. It is recommended that all personnel conducting oil burn ignitions fully comply with wearing the required PPE during every ignition as dictated in the safety operations protocols.

While no over-exposures attributable to the in-situ burns were identified, NIOSH investigators recommend that in-situ burns be conducted with all vessels positioned upwind at an adequate distance away from the fire. For fire safety reasons, all vessels involved should remain as far away from the fire as possible as established in the site safety plan. Every effort should be made to keep workers from the area of the smoke plume, and to evacuate them as quickly as possible when changing conditions may put them in the area of the contaminants from the burn. Based on the monitoring data collected during this evaluation, continuous wearing of respirators is not warranted. However, sudden or unexpected shifts in winds or other emergency situations may cause exposure to the smoke plume. During these emergency situations, respiratory protection may be needed while evacuating the area. Escape respirators may be a suitable option in such circumstances. Respirators should be used in accordance with OSHA standard 29 CFR.1910.134.

The NIOSH industrial hygienists observed widespread use of tobacco products, including cigarettes and smokeless tobacco (also known as dip or snuff), among the worker populations on all the vessels of the in-situ burn team. Cigarette use by workers outside on the decks of vessels as well as inside cabins was observed. Smoking is the single most preventable cause of disease, disability, and death in the United States; an estimated 443,000 people die prematurely from smoking or exposure to secondhand smoke, and another 8.6 million have a serious illness caused by smoking. [CDC, 2010]. While eliminating or reducing cigarette smoking among Deepwater Horizon response workers is desirable, at a minimum, NIOSH industrial hygienists recommend that workers on board vessels refrain from smoking inside cabins. This will help reduce exposures to secondhand smoke.

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Table 1. Analytical methods used for substances evaluated during the June 8–10, 2010 in-situ burns

Anayte	**Method**
Acetaldehyde	OSHA* 52/NMAM† 2501
Acrolein	OSHA 52/NMAM 2501
Benzene	NMAM 1501‡
Benzene-soluble fraction	NMAM 5042
Carbon monoxide	Direct reading—GasAlert CO Extreme, BW Technologies Ltd., Calgary, Canada
Diesel exhaust (elemental carbon, organic carbon, total carbon)	NMAM 5040
Ethyl benzene	NMAM 1501‡
Formaldehyde	OSHA 52/NIOSH 2501
Hydrogen sulfide	Direct reading—GasAlert H_2S Extreme, BW Technologies Ltd., Calgary, Canada
Mercury	NMAM 6009
Naphthalene	NMAM 1501‡
Relative humidity	Direct reading—HOBO® H8 ProSeries, Onset Computer Corporation, Bourne, Massachusetts
Temperature	Direct reading—HOBO® H8 ProSeries, Onset Computer Corporation, Bourne, Massachusetts
Total Hydrocarbons	NMAM 1501‡
Toluene	NMAM 1501‡
Volatile organic compounds (Screening)	NMAM 2549 and EPA§ TO-15
Xylene (Total)	NMAM 1501‡

*Occupational Safety and Health Administration [OSHA Analytical Laboratory 1985]
†National Institute for Occupational Safety and Health (NIOSH) Manual of Analytical Methods [NIOSH 2010]
‡Analysis for selected volatile organic compounds by an adaptation of the method
§Environmental Protection Agency [EPA 1999]

Table 2. Occupational exposure limits for substances evaluated during the June 8–10, 2010 in-situ burns				
Chemical	**NIOSH REL[a]**	**OSHA PEL[b]**	**ACGIH TLV[c]**	**AIHA WEEL[d]**
Acetaldehyde	N/A[e]	200 ppm TWA[f]	25 ppm Ceiling	N/A
Acrolein	0.1 ppm TWA 0.3 ppm STEL[g]	0.1 ppm TWA	0.1 ppm Ceiling	N/A
Benzene	0.1 ppm TWA 1 ppm STEL	1 ppm TWA 5 ppm STEL 0.5 ppm Action Level	0.5 ppm TWA 2.5 ppm STEL	N/A
Benzene-soluble fraction of total particulate	N/A	N/A	0.5 mg/m^3 TWA[h]	N/A
Carbon monoxide	35 ppm TWA 200 ppm Ceiling	50 ppm TWA	25 ppm TWA	N/A
Diesel exhaust (as elemental carbon)[i]	N/A	N/A	N/A	N/A
Ethyl benzene	100 ppm TWA 125 ppm STEL	100 ppm TWA	100 ppm TWA[j] 125 ppm STEL	N/A
Formaldehyde	0.016 ppm TWA 0.1 ppm Ceiling[k]	0.75 ppm TWA	0.3 ppm Ceiling	N/A
Hydrogen sulfide	10 ppm Ceiling	20 ppm Ceiling[l]	1 ppm TWA 5 ppm STEL	N/A
Mercury	0.05 mg/m^3 TWA[m]	0.1 mg/m^3 TWA[n]	0.025 mg/m^3 TWA[n]	N/A
Naphthalene	10 ppm TWA 15 ppm STEL	10 ppm TWA	10 ppm TWA 15 ppm STEL	N/A
Total hydrocarbons	350 mg/m^3 TWA 1800 mg/m^3 Ceiling (Petroleum distillates)	2000 mg/m^3 TWA (Petroleum distillates as naphtha)	200 mg/m^3 TWA (Kerosene as total hydrocarbon vapor)	N/A
Toluene	100 ppm TWA 150 ppm STEL	200 ppm TWA 300 ppm Ceiling 500 ppm Peak	20 ppm TWA	N/A

Table 2. Occupational exposure limits for substances evaluated during the June 8–10, 2010 in-situ burns (continued)

Chemical	NIOSH REL[a]	OSHA PEL[b]	ACGIH TLV[c]	AIHA WEEL[d]
Xylene	100 ppm TWA 150 ppm STEL	100 ppm TWA	100 ppm TWA 150 ppm STEL	N/A

[a]National Institute for Occupational Safety and Health (NIOSH) recommended exposure limit (REL) [NIOSH 2005]
[b]Occupational Safety and Health Administration (OSHA) permissible exposure limit (PEL) [29 CFR 1910]
[c]American Conference of Governmental Industrial Hygienists® (ACGIH) threshold limit value® (TLV) [ACGIH 2010]
[d]American Industrial Hygiene Association (AIHA) Workplace Environmental Exposure Level (WEEL) [AIHA 2009]
[e]N/A = not applicable
[f]TWA = time weighted average
[g]STEL = short term exposure limit
[h]This OEL is for asphalt (bitumen) fume as benzene-soluble aerosol but was considered appropriate because this sampling was intended to differentiate between petroleum associated particulate and background particulate.
[i]California Department of Health Services' Hazard Evaluation System & Information Service (HESIS) guideline for diesel exhaust particles (measured as elemental carbon [EC]) is 20 µg/m^3 for an 8-hour TWA [CDHS 2002]
[j]Proposed to be changed to 20 ppm TWA and STEL eliminated [ACGIH 2010]
[k]15-minute ceiling
[l]Exposures shall not exceed with the following exception: if no other measurable exposure occurs during the 8-hour work shift, exposures may exceed 20 ppm, but not more than 50 ppm (peak), for a single time period up to 10 minutes
[m]Elemental form
[n]Elemental and inorganic forms

Table 3. Environmental conditions during the June 8–9, 2010 in-situ burns*		
Vessel	**Temperature (°F)***	**Relative Humidity (%)***
June 8, 2010		
Dustin Michael (deck)	83–87; 84	61–78; 63
RHIB C (center of boat)	84–88; 86	58–77; 60
June 9, 2010		
Gulf Rambler (deck)	83–85; 84	68–69; 69
Gulf Rambler (cabin)	84–86; 84	65–70; 65
RHIB A (center of boat)	83–86; 84	66–67; 67

*Reported as range; average

Hours of monitoring: approximately 9:00 AM – 6:30 PM

Table 4. Personal breathing zone and area air concentrations for substances measured on June 8, 2010 on the Dustin Michael

Activity/Location	Substance	Sampling Information*		Sample Concentration†‡
		Time (min)	Volume (Liters)	
Personal Breathing Zone Air Samples—Worker A				
Safety Officer	Acetaldehyde	560	56.4	<0.004 ppm
Safety Officer	Acrolein	560	56.4	<0.02 ppm
Safety Officer	Benzene	565	117	<0.0005 ppm
Safety Officer	Ethyl benzene	565	117	0.0022 ppm
Safety Officer	Formaldehyde	560	56.4	<0.009 ppm
Safety Officer	Naphthalene	565	117	(0.0085 ppm)
Safety Officer	Total hydrocarbons	565	117	4.7 mg/m^3
Safety Officer	Toluene	565	117	0.0017 ppm
Safety Officer	Xylenes	565	117	0.0059 ppm
Area Air Samples				
Deck	Acetaldehyde	572	58.6	<0.004 ppm
Deck	Acrolein	572	58.6	<0.02 ppm
Deck	Benzene	574	117	<0.0005 ppm
Deck	Benzene soluble fraction	563	1120	(0.059 mg/m^3)
Deck	Carbon monoxide	578	N/A	0 ppm
Deck	Diesel exhaust	566	1110	EC: 2.4 µg/m^3; OC: 33 µg/m^3
Deck	Ethyl benzene	574	117	0.0017 ppm
Deck	Formaldehyde	572	58.6	<0.008 ppm
Deck	Hydrogen sulfide	578	N/A	0 ppm
Deck	Mercury	412	84.5	<0.00002 mg/m^3
Deck	Naphthalene	574	117	(0.0085 ppm)
Deck	Total hydrocarbons	574	117	3.8 mg/m^3
Deck	Toluene	574	117	0.0020 ppm
Deck	Xylenes	574	117	0.0049 ppm

*N/A = not applicable
†Concentrations reported as "<" were not detected; the given value is the minimum detectable concentration
‡Concentrations in parentheses were between the minimum detectable concentration and the minimum quantifiable concentration (parentheses are used to point out there is more uncertainty associated with these values than values above the minimum quantifiable concentration)

Table 5. Personal breathing zone and area air concentrations for substances measured on June 8, 2010 on the rigid-hulled inflatable boat C

Activity/Location	Substance	Sampling Information* Time (min)	Sampling Information* Volume (Liters)	Sample Concentration†‡
Personal Breathing Zone Air Samples—Worker B				
Ignition and spotting of oil, and boom repair§	Acetaldehyde	315	32.1	<0.007 ppm
Ignition and spotting of oil, and boom repair§	Acetaldehyde	308	30.9	<0.007 ppm
Ignition and spotting of oil, and boom repair§	Acrolein	315	32.1	<0.04 ppm
Ignition and spotting of oil, and boom repair§	Acrolein	308	30.9	<0.04 ppm
Ignition and spotting of oil, and boom repair	Benzene	489	99.6	(0.0015 ppm)
Ignition and spotting of oil, and boom repair	Carbon monoxide	487	N/A	Range: 0–155 ppm; Avg: 3 ppm
Ignition and spotting of oil, and boom repair	Ethyl benzene	489	99.6	0.0046 ppm
Ignition and spotting of oil, and boom repair§	Formaldehyde	315	32.1	<0.02 ppm
Ignition and spotting of oil, and boom repair§	Formaldehyde	308	30.9	<0.02 ppm
Ignition and spotting of oil, and boom repair	Hydrogen sulfide	483	N/A	0 ppm
Ignition and spotting of oil, and boom repair	Naphthalene	489	99.6	(0.010 ppm)
Ignition and spotting of oil, and boom repair	Toluene	489	99.6	0.0037 ppm
Ignition and spotting of oil, and boom repair	Total hydrocarbons	489	99.6	8.5 mg/m^3
Ignition and spotting of oil, and boom repair	Xylenes	489	99.6	0.011 ppm
Personal Air Samples—Worker C¶				
Ignition of oil	Benzene	79	16.1	(0.0059 ppm)
Ignition of oil	Ethyl benzene	79	16.1	(0.0066 ppm)
Ignition of oil	Naphthalene	79	16.1	(0.023 ppm)
Ignition of oil	Toluene	79	16.1	0.018 ppm
Ignition of oil	Total hydrocarbons	79	16.1	9.1 mg/m^3
Ignition of oil	Xylenes	79	16.1	0.024 ppm
Area Air Samples				
Center of RIHB	Benzene	423	85.4	(0.0017 ppm)
Center of RIHB	Benzene soluble fraction	474	939	< 0.06 mg/m^3
Center of RIHB	Diesel exhaust	463	897	EC: 3.7 $\mu g/m^3$; OC: 43 $\mu g/m^3$
Center of RIHB	Ethyl benzene	423	85.4	0.0032 ppm
Center of RIHB	Mercury	477	95.7	< 0.00002 mg/m^3

Table 5. Personal breathing zone and area air concentrations for substances measured on June 8, 2010 on the rigid-hulled inflatable boat C (continued)

Activity/Location	Substance	Sampling Information*		Sample Concentration†‡
		Time (min)	Volume (Liters)	
Area Air Samples (continued)				
Center of RIHB	Naphthalene	423	85.4	(0.012 ppm)
Center of RIHB	Toluene	423	85.4	0.0040 ppm
Center of RIHB	Total hydrocarbons	423	85.4	6.7 mg/m^3
Center of RIHB	Xylenes	423	85.4	0.0095 ppm

*N/A = not applicable
†Concentrations reported as "<" were not detected; the given value is the minimum detectable concentration
‡Concentrations in parentheses were between the minimum detectable concentration and the minimum quantifiable concentration (parentheses are used to point out there is more uncertainty associated with these values than values above the minimum quantifiable concentration)
§Samples collected side-by-side
¶Worker smoked

Table 6. Personal breathing zone and area air concentrations for substances measured on June 9, 2010 on the Gulf Rambler

Activity/Location	Substance	Sampling Information*		Sample Concentration†‡
		Time (min)	Volume (Liters)	
Personal Breathing Zone Air Samples—Worker D§				
Boat Captain	Acetaldehyde	528	54.6	< 0.004 ppm
Boat Captain	Acrolein	528	54.6	<0.02 ppm
Boat Captain	Benzene	323	65.2	<0.001 ppm
Boat Captain	Carbon monoxide	541	N/A	Range: 0–17 ppm; Avg: 2 ppm
Boat Captain	Ethyl benzene	323	65.2	(0.0010 ppm)
Boat Captain	Formaldehyde	528	54.6	<0.009 ppm
Boat Captain	Naphthalene	323	65.2	(0.0047 ppm)
Boat Captain	Total hydrocarbons	323	65.2	1.1 mg/m^3
Boat Captain	Toluene	323	65.2	(0.0025 ppm)
Boat Captain	Xylenes	323	65.2	(0.0046 ppm)
Area Air Samples¶				
Deck	Acetaldehyde	520	54.1	< 0.004 ppm
Deck	Acrolein	520	54.1	<0.02 ppm
Cabin	Benzene	517	107	(0.00062 ppm)
Deck	Benzene	521	109	0.0027 ppm
Deck	Benzene soluble fraction	530	1050	< 0.06 mg/m^3
Deck	Carbon monoxide	537	N/A	Range: 0–17 ppm; Avg: 1 ppm
Deck	Diesel exhaust	528	1040	EC: 6.2 $\mu g/m^3$; OC: 46 $\mu g/m^3$
Cabin	Ethyl benzene	517	107	(0.0013 ppm)
Deck	Ethyl benzene	521	109	(0.0011 ppm)
Deck	Formaldehyde	520	54.1	<0.009 ppm
Deck	Hydrogen sulfide	536	N/A	0 ppm
Deck	Mercury	527	109	< 0.00002 mg/m^3
Cabin	Naphthalene	517	107	0.0066 ppm
Deck	Naphthalene	521	109	(0.0044 ppm)
Cabin	Total hydrocarbons	517	107	1.7 mg/m^3
Deck	Total hydrocarbons	521	109	1.4 mg/m^3
Cabin	Toluene	517	107	0.0020 ppm
Deck	Toluene	521	109	0.0023 ppm
Cabin	Xylenes	517	107	0.0058 ppm
Deck	Xylenes	521	109	0.0042 ppm

*N/A = not applicable
†Concentrations reported as "<" were not detected; the given value is the minimum detectable concentration
‡Concentrations in parentheses were between the minimum detectable concentration and the minimum quantifiable concentration (parentheses are used to point out there is more uncertainty associated with these values than values above the minimum quantifiable concentration)
§Worker smoked
¶Smoking was permitted inside the vessel cabin

Table 7. Personal breathing zone and area air concentrations for substances measured on June 9, 2010 on the rigid-hulled inflatable boat A

Activity/Location	Substance	Sampling Information*		Sample Concentration†‡
		Time (min)	Volume (Liters)	
Personal Breathing Zone Air Samples—Worker E				
Ignition and spotting of oil§	Acetaldehyde	537	50.3	<0.004 ppm
Ignition and spotting of oil§	Acetaldehyde	538	56.2	<0.004 ppm
Ignition and spotting of oil§	Acrolein	537	50.3	<0.03ppm
Ignition and spotting of oil§	Acrolein	538	56.2	<0.02 ppm
Ignition and spotting of oil	Benzene	538	114	0.0024 ppm
Ignition and spotting of oil	Carbon monoxide	534	N/A	Range: 0–220 ppm; Avg: 3 ppm
Ignition and spotting of oil	Ethyl benzene	538	114	0.0017 ppm
Ignition and spotting of oil§	Formaldehyde	537	50.3	<0.01 ppm
Ignition and spotting of oil§	Formaldehyde	538	56.2	<0.009 ppm
Ignition and spotting of oil	Naphthalene	538	114	(0.0022 ppm)
Ignition and spotting of oil	Toluene	538	114	0.0075 ppm
Ignition and spotting of oil	Total hydrocarbons	538	114	1.1 mg/m^3
Ignition and spotting of oil	Xylenes	538	114	0.0073 ppm
Personal Breathing Zone Air Samples—Worker F¶**				
Ignition and spotting of oil	Benzene	280	58.3	(0.0018 ppm)
Ignition and spotting of oil	Ethyl benzene	280	58.3	0.0063 ppm
Ignition and spotting of oil	Hydrogen sulfide	278	N/A	0 ppm
Ignition and spotting of oil	Naphthalene	280	58.3	(0.0027 ppm)
Ignition and spotting of oil	Toluene	280	58.3	0.0068 ppm
Ignition and spotting of oil	Total hydrocarbons	280	58.3	2.8 mg/m^3
Ignition and spotting of oil	Xylenes	280	58.3	0.0091 ppm
Area Air Samples				
Center of RIHB	Benzene soluble fraction	526	1050	<0.06 mg/m^3
Center of RIHB	Diesel exhaust	526	1030	EC: 2.9 $\mu g/m^3$; OC: 46 $\mu g/m^3$
Center of RIHB	Mercury	529	109	<0.00002 mg/m^3

*N/A = not applicable
†Concentrations reported as "<" were not detected; the given value is the minimum detectable concentration
‡Concentrations in parentheses were between the minimum detectable concentration and the minimum quantifiable concentration (parentheses are used to point out there is more uncertainty associated with these values than values above the minimum quantifiable concentration)
§Samples collected side-by-side
¶Worker was on the RIHB for approximately four and a half hours on this day, remainder of the day was spent aboard the Premier Explorer
**Worker smoked

Table 8. Health symptom survey—demographics by vessel

	Premier Explorer	Sea Fox	Unexposed*
Number of participants	17	22	103
Age range	19–62	20–53	18–70
Race			
White	82%	86%	40%
Hispanic	0%	0%	29%
Asian	6%	0%	9%
Black	0%	4%	19%
Other	0%	0%	3%
Not given	12%	0%	0%
Male	94%	100%	96%
Days worked oil spill	3–70	3–47	0–45
Days worked boat	3–70	2–47	0

*Participants were recruited from the Venice Field Operations Branch and the Venice Commanders' Camp. Those who reported that they had not worked on boats and had no exposures to oil, dispersant, cleaner, or other chemicals were included in this group.

Table 9. Health symptom survey—reported injuries and symptoms by vessel			
	Premier Explorer	**Sea Fox**	**Unexposed***
Number of participants	17	22	103
Injuries			
Scrapes or cuts	4 (24%)	4 (18%)	11 (11%)
Burns by fire	0	0	1 (1%)
Chemical burns	0	2 (9%)	0
Bad Sunburn	2 (11%)	2 (9%)	8 (8%)
Constitutional symptoms			
Headaches	4 (24%)	6 (27%)	5 (14%)
Feeling faint, dizziness, fatigue or exhaustion, or weakness	5 (29%)	6 (27%)	13 (13%)
Eye and upper respiratory symptoms			
Itchy eyes	0	6 (27%)	5 (5%)
Nose irritation, sinus problems, or sore throat	4 (24%)	7 (32%)	16 (16%)
Metallic taste	0	2 (9%)	0
Lower respiratory symptoms			
Coughing	1 (6%)	6 (27%)	8 (8%)
Trouble breathing, short of breath, chest tightness, wheezing	0	3 (14%)	4 (4%)
Cardiovascular symptoms			
Fast heart beat	0	1 (5%)	1 (1%)
Chest pressure	0	0	0
Gastrointestinal symptoms			
Nausea or vomiting	0	1 (5%)	3 (3%)
Stomach cramps or diarrhea	0	4 (18%)	7 (7%)
Skin symptoms			
Itchy skin, red skin, or rash	1 (6%)	4 (18%)	8 (8%)
Musculoskeletal symptoms			
Hand, shoulder, or back pain	3 (18%)	5 (23%)	6 (6%)
Psychosocial symptoms			
Feeling worried or stressed, pressured, depressed or hopeless, short tempered, or frequent changes in mood	2 (12%)	5 (23%)	7 (7%)
Heat stress symptoms†			
Any	6 (35%)	10 (45%)	21 (20%)
4 or more symptoms	0	1 (5%)	3 (3%)

*Participants were recruited from the Venice Field Operations Branch and the Venice Commanders' Camp. Those who reported that they had not worked on boats and had no exposures to oil, dispersant, cleaner, or other chemicals were included in this group.
†Headache, dizziness, feeling faint, fatigue or exhaustion, weakness, fast heart beat, nausea, red skin, or hot and dry skin.

Health Hazard Evaluation of Deepwater Horizon Response Workers
HETA 2010-0115

Interim Report #2C
Evaluation of June 25, 2010, Barge Oil Vacuuming Operations in Coup Abel Pass, off Grand Isle, Louisiana

Introduction

Two National Institute for Occupational Safety and Health (NIOSH) industrial hygienists visually inspected oil skimming operations on a set of barges located in Coup Abel Pass, offshore from Grand Isle, Louisiana on June 25, 2010. Air samples for oil-related contaminants were not collected on this mission because very little oil was present around the barges on the day of the evaluation.

The barge oil vacuuming operation consisted of 18 barges moored together in the pass between two barrier islands separating the Gulf of Mexico from Barataria Bay, near Grand Isle, Louisiana. The barges were divided into six sets of three barges each, with each set containing a semi-truck fitted with a vacuuming system. Plans were underway to have additional barge vacuuming operations at other passes into Barataria Bay. There were approximately twelve vacuum operators on the barges as well as additional support staff (management, emergency medical technician, pile driver operators, and U.S. Coast Guard personnel).

Evaluation

Figure 1. Workers using a vacuum hose to remove potential oil contaminated plant material from the water surface

The NIOSH investigators observed two workers vacuuming floating plant material that was possibly contaminated with oil. To perform this task, the two workers extended a 2" diameter rubber vacuum hose over the side of the barge deck and lowered it approximately 8' to the water surface to vacuum oil and potentially oil contaminated plant material from the water surface near the side of the barges (Figure 1). Workers either bent forward at the waist or kneeled to maneuver the hose nozzle at the water surface. Workers wore work boots, hardhats, safety glasses, and personal floatation devices during vacuuming operations. A few workers wore safety harnesses. The harnesses were not tied off to any structure on the barges to arrest the workers' fall. Shade tents were available for workers at each vacuum truck. Workers were observed to be resting under the shade tents when they were not operating the vacuum trucks. Signage on the vacuum trucks indicated a high noise area but workers did not wear hearing protection when vacuum trucks were operating. During our observations workers only vacuumed for approximately 15 minutes. However, workers may perform this task for a full 12-hour work shift.

The NIOSH investigators also observed pilings being sunk into the sea floor using a pile driver. Pilings are used as an anchor point to keep the barges in place in the pass. This process created loud impact noise in the area close to the pile driver. Workers in the area, including those working on the pile driving vessel, did not wear hearing protection during pile driving activities.

Recommendations

1. Ensure that adequate fall protection is provided and used correctly on the barges according to applicable regulatory agency regulations (OSHA, U.S Coast Guard, and/or Bureau of Ocean Energy Management, Regulation and Enforcement). NIOSH recommends that an unprotected side or edge which is 6 feet or more above a lower level should be protected from falling by the use of a guardrail system, safety net system, or personal fall arrest system [NIOSH 2009]. A fall protection program, including employee training, should be in place before providing workers with safety harnesses to ensure that the devices are used correctly. Additional information on fall protection can be found at the NIOSH website (http://www.cdc.gov/niosh/topics/falls/) and OSHA website (http://www.osha.gov/SLTC/fallprotection/index.html).
2. Provide hearing protection (ear plugs and/or ear muffs) to workers near vacuum or pile driving operations , unless or until noise monitoring data indicates that noise exposures are below NIOSH recommended limits. If not already completed, personal noise dosimetry measurements over a full work shift should be collected on workers near vacuum and pile driving operations. If hearing protection is shown to be needed, workers must be trained to wear hearing protection correctly. Steps should be taken by BP to ensure that all applicable regulatory agency (OSHA, U.S Coast Guard, Bureau of Ocean Energy Management, Regulation and Enforcement) occupational noise exposure regulations are followed. NIOSH recommends that employees with noise exposures greater than the recommended exposure limit of 85 decibels, A-weighted, be included in a hearing loss prevention program. Additional information on occupational noise exposure and preventing hearing loss can be found on the NIOSH website (http://www.cdc.gov/niosh/topics/noise/) and OSHA website (http://www.osha.gov/SLTC/noisehearingconservation/standards.html).
3. Take steps to reduce the potential for musculoskeletal disorders from working in awkward positions. These may include work rotation, providing kneeling supports or knee pads, or using v-shaped pipe roller stands that could support the weight of the hose and eliminate bending during vacuuming. Additional information on methods to reduce ergonomic hazards can be found on the NIOSH website (http://www.cdc.gov/niosh/topics/ergonomics/).

References

NIOSH [2009]. Workplace safety and health topics-falls from elevations http://www.cdc.gov/niosh/topics/falls/]. Date accessed: July 2010.